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Diseases of SMALL GRAINS *in Texas*

in cooperation with the
UNITED STATES DEPARTMENT OF AGRICULTURE

TEXAS AGRICULTURAL EXPERIMENT STATION
R. D. LEWIS, DIRECTOR, COLLEGE STATION, TEXAS

DIGEST

Diseases of small grains are important factors in the growing of these crops for grain or forage in Texas. Damage to the crop may result from reduced stands, reduction in amount or quality of forage or in reduced yields and quality of the grain produced. Losses from diseases occur nearly every year. In excessively wet seasons, such as 1957 and 1958, these losses were estimated to be more than 20,000,000 bushels of grain.

The control or reduction of losses from many small grain diseases in Texas is not only of local importance, but has national and international significance. The fall infection, winter survival and spring increase in South Texas of airborne pathogens, such as the cereal rusts, may endanger the small grain crops throughout Texas and other states.

Diseases of wheat, which consistently cause losses or are potentially dangerous to the crop, include leaf rust, stem rust, speckled leaf blotch and loose and covered smut or bunt. Less frequently present and usually less damaging diseases are stripe rust, mildew, Septoria glume blotch and foot-rot. A brief description of these diseases is given with suggested control measures where these are known.

The two most serious diseases of oats in Texas are crown rust and the Helminthosporium blights. Stem rust is a potential threat to the crop every year. Smuts take a moderate toll each season, but can be controlled easily by seed treatment. Recently, the Septoria diseases, powdery mildew and yellow dwarf, have caused local area losses and these diseases may become important in Texas. A brief description of these diseases is given, with suggested measures for reducing losses.

Net blotch, leaf rust, mildew and the smuts cause some damage to barley nearly every year. Barley may serve as an overwintering host for stem rust of wheat. Bacterial blight, false stripe, scald and yellow dwarf cause losses less frequently in Texas. A brief description of these diseases is given, with suggested means for control or reducing losses.

The treatment of all small grain planting seed with approved fungicides is recommended. Such treatment controls seedborne pathogens and may reduce infection from pathogens in the soil or crop residue. Extensive research is underway to find fungicides capable of controlling such pathogens as the rusts. While some promising materials of this type have been discovered, they are not now practical for use on low-per-acre-value crops such as the small grains.

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Diseases of Small Grains in Texas

I. M. Atkins and M. C. Futrell *

SMALL GRAINS ARE GROWN extensively in Texas for grain or forage, or for combinations of the two. A recent survey showed that all but 18 of the 254 Texas counties grew some acreage of small grain. The concentration of acreages varies with the crop and with the section of the State. The estimated harvested areas for the 10-year period, 1947-56, were 3,634,000 acres of wheat, 1,130,900 acres of oats and 120,200 acres of barley. Unofficial estimates made in 1957 indicate that an additional one million acres are seeded exclusively for forage.

Losses from diseases are important factors in the growing of small grain crops in Texas. The mild, humid winters of the southern half of the State and the long period of seedling growth favor the establishment, survival, increase and spread of many diseases. While these diseases have mostly prevented the growing of small grains for grain, these crops have recently become an important source of winter pasture in South Texas. Diseases which become established in fall-sown grain of South Texas may overwinter in this area and then spread to the larger commercial grain growing areas farther north in Texas and other states.

*Respectively agronomist in charge of small grain research Texas Agricultural Experiment Station and Crops Research Division, Agricultural Research Service, U. S. Department of Agriculture; and plant pathologist, Crops Research Division, Agricultural Research Service, U. S. Department of Agriculture, College Station, Texas.

Losses from diseases may occur in many ways, such as reduced stands as a result of either seed-borne or soilborne pathogens; the foilage may be killed or damaged so that its value for forage is reduced in quality or quantity; the pathogens may attack the plant during the fruiting period and cause reduced yield, shriveled seed or lodging of the crop; and the grain may be destroyed by smut or damaged in quality by the presence of smut balls so that it grades "smutty" and brings a lower return at the market.

Losses from plant diseases are staggering when viewed from the standpoint of reductions in total production of Texas grain crops. Unusually severe losses occurred in 1935, 1949 and 1957, as shown in Table 1. These are not intended to indicate normal losses to be expected, but only to show the tremendous loss in income that can occur when conditions are favorable for the spread of diseases. The loss in most years is much less and in some seasons almost negligible.

The very high losses shown in Table 1 occurred in seasons having high rainfall and high humidity over large areas of the State. Widespread, severe losses usually depend on a series of conditions and events favorable for disease development as the crops mature progessively from

TABLE 1. ESTIMATES OF LOSSES FROM SMALL GRAIN DISEASES IN TEXAS, 1935, 1949 AND 1957

Crop and disease	Estimated loss in					
	1935		1949		1957	
	Percent	Bushels	Percent	Bushels	Percent	Bushels
WHEAT						
Leaf rust	2.0	237,000	11.1	12,436,350	3.9	1,468,111
Stem rust	10.0	1,185,000	4.8	5,845,100	0.7	245,157
Septoria[1]			3.4	4,217,550	5.0	1,866,981
Smuts			.2	179,310	Tr	13,095
Others	3.5	295,000	1.1	1,343,235	1.1	416,522
Total	15.5	1,717,000	20.5	24,021,545	10.7	4,009,904
OATS						
Crown rust	2.0	954,000	9.0	3,166,800	11.2	5,821,220
Stem rust	10.0	2,386,000	8.9	2,932,800	2.3	1,166,542
Helminthosporium[1]			3.6	1,170,000	13.7	7,059,696
Smuts			0.4	175,500	0.3	134,524
Others					0.8	398,177
Total	12.0	3,340,000	21.9	7,445,100	28.1	14,580,541
BARLEY						
Leaf rust			0.9	26,400	1.1	61,068
Stem rust	5.0	146,000	Tr		0.2	10,042
Helminthosporium[1]	0.2	6,000	3.7	105,600	5.2	281,850
Mildew						
Others	4.0	87,000	2.3	61,600		
Total	9.2	239,000	6.9	193,600	6.5	352,960

[1]Includes loss from several species.

Figure 1. A normal leaf of wheat is shown at the left in contrast with a leaf and stems of wheat infected with stem rust.

south to north in Texas. Among other things, these include abundant inoculum, susceptible varieties grown over large areas and favorable weather conditions. In other seasons, this chain of events or conditions may be broken by a situation in one area that may block the spread of inoculum to other areas. Such situations may be produced by drouth unfavorable temperatures or resistant varieties. This break may cause the disease to be confined to a small area or to certain crops or varieties.

DISEASES OF WHEAT

Texas annually grows an estimated 3,634,000 acres of wheat distributed 64 percent in the Panhandle or on the High Plains, 28 percent on the Rolling Plains and North Central Prairie and 8 percent on the Grand Prairie, Central Blackland and Edwards Plateau. While most of the wheat is grown in low-rainfall areas, some is scattered from the Red River southward to the vicinity of San Antonio in such manner that it may serve as a continuing host for diseases such as the rusts. The spores of these diseases are easily airborne and they may spread from field to field from overwintering areas of South Texas into the principal commercial grain areas.

Figure 2. A field of wheat completely destroyed by stem rust at College Station in 1954.

Stem Rust

Stem rust (black stem rust) (*Puccinia graminis* var. *tritici* Eriks. & E. Henn.) is caused by a fungus that attacks the stems, leaves and heads of the wheat plant. It appears as long, narrow, brick-red pustules that produce thousands of tiny, red, egg-shaped spores (urediospores). These spores perform the same function for the fungus as seed do for a crop plant. They are carried by wind currents to nearby plants, to other fields or for longer distances. The spores must have free moisture from dew or rain to germinate; hence, the old theory that rain causes rust. When the spore germinates, it produces a germ tube that enters the host tissue through natural openings, such as the stomata, and produces new pustules in 5 to 10 days. The disease can spread rapidly under favorable conditions because of the tremendous number of spores and the short time required for reproduction. High infection of stem rust results in shriveled grain, lodged stems and lowered yield. Figure 1 shows pustules of stem rust and Figure 2 a field of wheat completely destroyed by stem rust.

The causal fungus of stem rust has a complex life cycle in which the sexual stage of the organism occurs on the common barberry, *Berberis* vulgaris and some other species. However, this sexual stage is not known to occur in Texas. Genetic recombination occurs on this alternate host and this may give rise to new races of rust. New races also may arise by hyphal fusion in the wheat plant. Races may be likened to varieties of a crop plant and are identified by their reaction on certain wheat varieties. There are more than 300 known races of stem rust of wheat. Wheat stem rust attacks barley, rye and certain grasses, but it does not attack oats. The disease gets its name, black stem rust, from the fact that, as the grain matures, a new kind of spore (teliospore) is formed. This is black in color instead of red. This is the beginning of the sexual stage of the organism.

Table 2 shows the reaction of a selected group of wheat varieties to certain races of stem rust.

TABLE 2. REACTIONS OF A SELECTED GROUP OF WHEAT VARIETIES TO SIX RACES OF STEM RUST

Variety	Race					
	15B	17	29	38	48A	56
Austin	S	R	R	R	R	R
Bowie	R	MR	S	R	S	R
Concho	S	R	R	S	R	S
Stewart	S	R	R	R	R	R
Langdon	R	R	R	R	R	R

R=resistant. S=susceptible.

Figure 3 demonstrates the seedling reaction of certain varieties of wheat when inoculated with stem rust in the greenhouse. This reaction is based on a scale of 1, highly resistant, to 4, fully susceptible. The reactions of a selected group of varieties are used in identifying races of rust.

The only practical control of stem rust at present is growing resistant varieties. Breeding work to develop such varieties was started at the Texas Agricultural Experiment Station in 1928. The Austin variety, resistant to races prevalent at that time, was distributed in 1941. Seabreeze, Supremo, Frisco, Quanah and Crockett varieties have since been developed and distributed to growers. Each is resistant to certain races and has given some protection from rust damage. No commercial variety adapted to Texas is resistant to all races. Quanah is resistant to some races and also has a degree of field tolerance to other races which usually permits it to escape serious damage. Additional breeding work to combine resistance to prevalent races with other desirable characteristics is in progress.

The mild climate of northern Mexico and South Texas makes it possible for rust to overwinter and creates a threat to the major wheat-producing belt of the Midwestern States. Rust spores may be blown long distances by winds and major storm disturbances. Control of rusts in this area, therefore, affords protection to crops used for forage and grain in this area and a reduction of the amount of inoculum blown northward into the extensive wheat-producing areas. Figure 4 shows how windborne spores of rust are carried from Mexico to the United States and in successive movements into Canada. The return movement southward occurs in the fall and early winter as cold air masses move spores back into South Texas. Information on this map is based on observations of wind movements, surveys of the occurrence of rust, identification of races and other conditions during 1954-56.

Important factors in determining whether a farmer will sustain loss from the rusts in a given year are weather conditions, mass air movements, the time and amount of original infection, the rust races present and the wheat varieties grown. The influence of these factors may be illustrated in the following discussion.

Race 15B of stem rust originated and was observe for several years prior to 1950, but it did not become widely prevalent in the principal wheat growing areas until that time. This race caused widespread and serious losses, particularly in durum wheat during 1950-54. Scientists in Mexico, United States and Canada developed and distributed several new varieties in an effort to reduce these losses Lerma and Kentana were released in northern Mexico; Bowie and Travis were developed for growing in South Texas, but were not released; and Selkirk was developed in Canada and released in Canada and the Northern States.

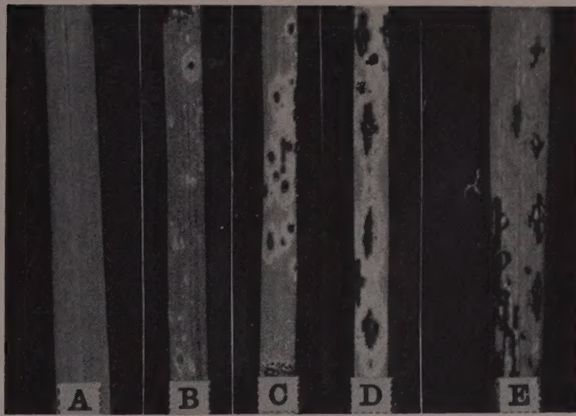

Figure 3. Reaction of wheat varieties to a race of stem rust: A—rust free or immune; B—resistant; C—moderately resistant; D—moderately susceptible; and E—susceptible.

The new varieties were resistant to race 15B, but were susceptible to one or more less prevalent races, such as 17, 29 and 48A. With the commercial growing of Lerma and Kentana in northern Mexico, an opportunity was present for the rapid increase of races 17, 29 and 48A and the exclusion of race 15B. Consequently, stem rust again became a factor in wheat growing during the winter in northern Mexico. Weather records show several mass air movements from this area across the Southern States in the spring of 1954. Evidence from infection on Bowie wheat, grown experimentally throughout this area, indicates that these races were carried throughout this area, as shown in Figure 4.

The widespread distribution of race 17, 29 and 48A and the consequent damage to Bowie and Travis wheat in experimental tests in Texas forced cancellation of plans to distribute these varieties. The influence of these races on yield

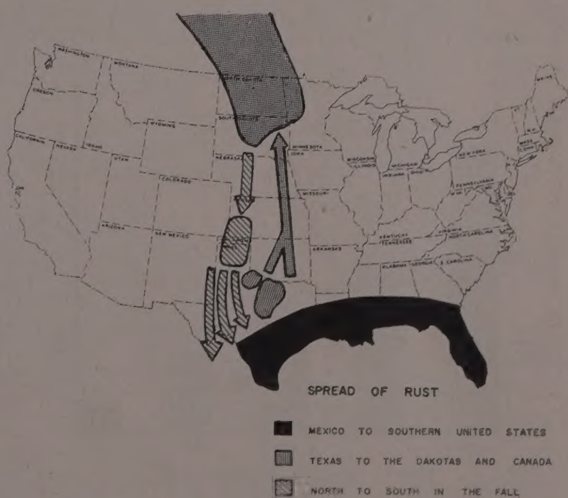

Figure 4. The pattern of wind movement of rust urediospores from Mexico to the United States and Canada.

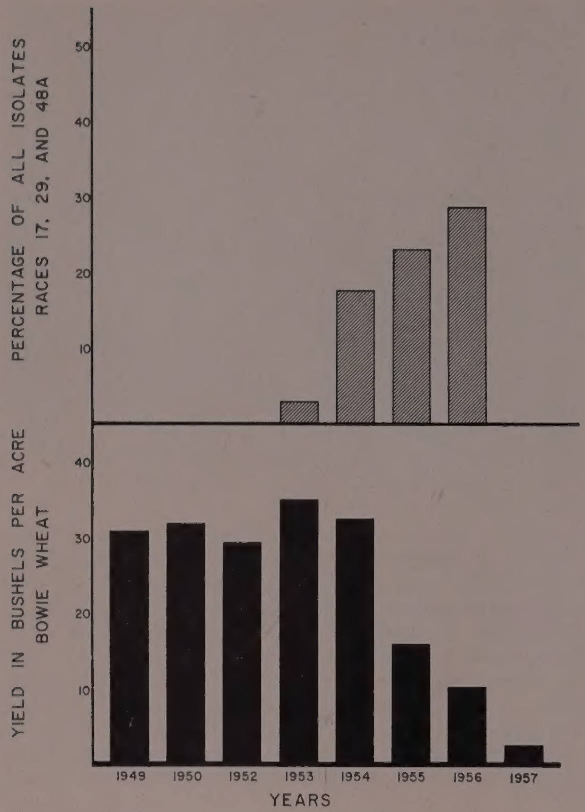

Figure 5. Yield of Bowie wheat and abundance of certain races of stem rust at College Station, 1949-57.

of Bowie wheat is given in Figure 5 where Bowie shows high yields during 1949-54, but produced low yields of shriveled grain in later years.

Systemic fungicides and antibiotics are being tested for their value in controlling rust. While a few of these will protect the plants, they are not now economically practical. For example, the yield of Bowie wheat grown at College Station in 1958, was increased from 18 to 57 bushels per acre by spraying with maneb every 5 days. Because the crop is susceptible for several months, the cost of such sprays is prohibitive. New materials may be developed which will make such spraying practical.

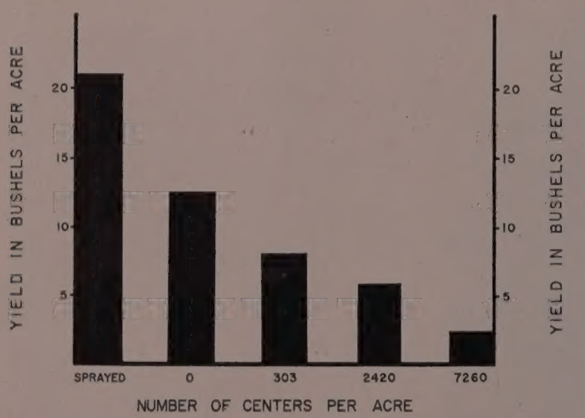

Figure 6. Effect of the number of stem rust-infection centers per acre on the yield of wheat compared with non-inoculated and sprayed control, College Station, 1957.

The time of infection, weather conditions and quantity of inoculum blown into a field during the fall in Texas are important factors in determing the damage that will occur. An experiment was conducted to determine the amount of damage that varying amounts of initial inoculum might cause when introduced into a field. Infection centers were established at 2-foot intervals (equivalent to 7,260 centers per acre), 4-foot intervals (2,420 centers per acre) and 6-foot intervals (303 centers per acre) in Bowie wheat at College Station in the fall of 1956. The spread of rust and yields of grain from these areas were compared with uninoculated plots and other plots where rust was controlled with maneb sprays. Data obtained in this experiment are shown in Figure 6. The plots where rust was controlled by sprays averaged 22 bushels per acre, while those where rust was introduced every 2 feet averaged only 3 bushels per acre.

The "fall-out" of spores brought in by strong wind movements may be determined by exposing small glass slides covered with vaseline, counting the spores and calculating the rate per area. The number of rust spores falling during the fall and spring may range from a few to thousands per square foot of area. Although most of these perish, it is evident that the opportunity for infection is tremendous should conditions be favorable.

Leaf Rust

Leaf rust of wheat (*Puccinia recondita* Rob. ex. Desm. f. sp. *tritici* (Eriks.) comb. nov.) is caused by a fungus parasite similar to that causing stem rust, but differing from it in many respects. The disease attacks the leaves and leaf sheaths, producing small, round, orange-red pustules. They may occur on either side of the leaf, but they do not extend through the entire leaf tissue as stem rust pustules usually do.

Leaf rust is favored by moderately cool weather in contrast with the warmer weather required for the rapid spread of stem rust. The disease may be found in Texas nearly any time during the fall, winter or spring. It often becomes established in the fall and continues to spread slowly all winter. Infected leaves become yellow and die prematurely when infection is high. The overwintering spores (teliospores) appear as black dots on the yellow or dead leaves. A normal leaf and leaves infected with varying percentages of leaf rust are shown in Figure 7.

The damage caused by leaf rust often is inconspicuous and many growers consider the disease of little importance. Closely controlled experiments show that infected leaves lose more water than normal leaves as photosynthetic tis-

Figure 7. Normal leaf of wheat (left) shown in contrast with leaves with varying degrees of leaf-rust infection.

Figure 8. Normal wheat leaf (left) in contrast with leaves infected with stripe rust.

sues are destroyed. Yields are reduced because of smaller seed and reduced seed setting. During severe epidemics some varieties fail to head, plants are weakened and lodge, tillering is reduced and the production of forage is lowered.

Considerable progress has been made in developing leaf rust-resistant varieties adapted to Texas conditions. No variety is resistant to all races prevalent in the State. Races are constantly changing in prevalence and new races may arise by hyphal fusion on the wheat plant. Varieties which are resistant at one time may later become susceptible when races of rust change or new ones arise.

Texas varieties with the highest degree of resistance to present races of leaf rust are Quanah, Ponca and Frisco. Crockett and Knox are susceptible in the seedling stage, but develop a high degree of resistance from the boot stage to maturity. Concho, Westar, Mediterranean, Austin, Seabreeze and Comanche are resistant to many races, but are susceptible to others.

A measure of the damage caused by leaf rust under field conditions is presented in Table 3. In years when leaf rust was not prevalent at the locations given, Quanah and Crockett yielded approximately the same as Comanche and Wichita, but the yields of Quanah and Crockett were much higher in severe rust years.

Stripe Rust

Stripe rust (*Puccinia striiformis* West.) is a cool-season disease and, previous to 1957, had been observed in Texas only twice and then in only trace amounts. Wet, cool weather prevailed during the springs of 1957 and 1958 and the disease developed into an epidemic that spread across the entire State from south to north. Stripe rust attacks the leaf blades and sheaths as does leaf rust, but the lesions are concentrated between the leaf veins in long, narrow stripes. The fungus also attacks the glumes and developing seed and, as teliospores are produced, the wheat spike may become discolored so that the damage may be confused with that caused by glume

TABLE 3. ANNUAL AND AVERAGE YIELDS OF WICHITA, CROCKETT, COMANCHE AND QUANAH WHEAT, AT TWO LOCATIONS IN TEXAS, DURING YEARS OF LEAF-RUST EPIDEMICS AND IN RUST-FREE YEARS

Location and variety	Percent rust infection in epidemic years				Yield of grain, bushels, in epidemic years				Yield of grain, bushels, in rust-free years			
	1949	1950	1952	Average	1949	1950	1952	Average	1948	1953	1954	Average
STEPHENVILLE												
Wichita	65	90	25	60	12.5	17.3	18.0	15.9	13.8	10.8	6.0	10.2
Crockett	0	10	20	10	12.7	28.0	24.7	21.8	25.0	14.7	6.7	15.5
Comanche	35	50	35	40	12.9	22.2	18.6	17.9	20.8	26.8	4.9	17.5
Quanah	0	15	Tr	5	12.7	40.2	20.8	24.8	23.9	14.4	6.6	18.3
									1951	1952	1953	Average
CHILLICOTHE												
Wichita	95	20		56	31.4	30.2		30.8	20.7	21.7	14.4	18.9
Crockett	Tr	10		5	41.5	35.2		38.4	23.7	22.9	10.5	19.0
Comanche	65	5		35	24.0	31.1		27.6	18.8	24.8	12.4	18.7
Quanah	5	0		2.5	33.0	31.9		32.5	17.2	20.0	8.9	15.4

Figure 9. Leaves infected with speckled leaf blotch are shown in contrast with a normal leaf at the right.

blotch. The pustules and spores are bright yellow. A normal wheat leaf and leaves infected with stripe rust are shown in Figure 8.

Observations on the reaction of some commercial varieties of wheat to stripe rust under Texas conditions during 1957 and 1958 are shown in Table 4. Ponca, Quanah and RedChief appeared to be the most resistant. Wichita, Westar and Crockett were the most susceptible.

Figure 10. Normal head and stem of wheat (left) in contrast with a stem and head infected with glume blotch (right).

TABLE 4. REACTION OF CERTAIN HARD RED WINTER WHEAT VARIETIES TO STRIPE RUST AT THREE LOCATIONS IN TEXAS, 1957-58

Variety	Stripe rust response[1]		
	Amarillo 1957	Chillicothe 1958	Iowa Park 1958
Triumph		35MS	20MS
Wichita	50S	70S	55S
Early Blackhull	20MS	40MS	10MS
Crockett	20MS	40MS	30S
RedChief	5R	15R	5R
Blackhull		20MR	20MR
Bison	25S	50S	25S
Tenmarq	50S	45S	25S
Ponca		10R	5R
Comanche	25S	25MS	15MS
Westar	70S	85S	15S
Pawnee		50S	
Concho	50S	60S	15S
Kharkof	5R	5R	5R

[1]R = resistant, MR = moderately resistant, MS = moderately susceptible, S = susceptible.

Speckled Leaf Blotch

Speckled leaf blotch (*Septoria tritici* Rob.) is a cool-weather disease which occurs throughout the principal wheat-growing areas nearly every year. However, the damage caused is rather inconspicuous and is generally overlooked by growers, except in very wet seasons such as 1957. Moderate damage by killing of the leaf area or of lower leaves occurs nearly every year.

The disease appears first as pale green to yellow spots on the leaf. These are caused by the breakdown of chlorophyll just ahead of the invading pathogen in the tissue. The lesions enlarge as the pathogen invades new tissue. The lesion becomes brown as the tissue is killed, then later ashen gray as the fruiting bodies, pycnidia, are formed. These tiny pinpoint black pycnidia are evident in Figure 9. The disease is not destroyed by temperatures below freezing and may continue to spread throughout most of the winter under Texas conditions.

Adapted varieties resistant to speckled leaf blotch in 1957 include Crockett, RedChief and Mediterranean, while Quanah and Ponca showed considerable tolerance. Other measures of value in reducing damage by this disease include seed treatment with organic mercury fungicides to reduce seedling infection, rotation of crops and plowing under of crop residues to prevent infection from old straw, and destruction of volunteer crops.

Septoria Glume Blotch

The glume blotch (*Leptosphaeria nodorum* Muller, *Septoria nodorum* Berk. conidial stage) of wheat is less common than the speckled leaf blotch and severe epidemics have occurred in Texas only in seasons of excessive spring rainfall and below normal temperatures, such as those of 1957 and 1941. The fungus causing glume blotch attacks the culms and spikes causing

a characteristic blackening of the affected areas. The stems are weakened and may break or bend over just above the nodes. A head and stem of wheat damaged by glume blotch are shown in Figure 10 in contrast with a normal head and stem at left. Severe lodging, as shown in Figure 11, may occur as a result of the damage to the stems. Shriveling of seed and reduced yields result from such damage.

Relatively little is known about varietal resistance or susceptibility to this disease. Knox was especially susceptible in commercial fields of North Central Texas during 1957. Cultural measures and seed treatment may aid in reducing losses from the disease.

Powdery Mildew

Mildew (*Erysiphe graminis* D. C. f. sp. *tritici* El. Marchal) normally is of only minor importance even in the more humid parts of the State, but occasionally it causes severe damage in small areas. It usually occurs during the winter or early spring when humidity is high and temperatures moderate, and it disappears when warm weather prevails. Mildew appears on the leaf surface as a mass of white mycelium, but the leaf tissues are invaded by the organism at the same time. Water and plant food are taken from the host plant so the leaf tissue becomes yellow and then dies. Black fruiting bodies appear in this mass of mycelium as the leaf is killed. Normal and mildew-infected leaves of wheat are shown in Figure 12.

Yields of wheat grain and the value of the crop for winter pasture are reduced when mildew infection is severe. Growing resistant varieties is the only practical means of control. Under Texas conditions, the Austin, Coker 47-27, Atlas 66 and Knox soft wheat varieties are moderately resistant. The hard red winter wheat varieties, Crockett, Ponca, RedChief and Wichita, are moderately resistant.

Loose Smut

The loose smut (*Ustilago tritici* (Pers.) Rostr.) of wheat is normally most prevalent in the humid sections of Texas, but the widespread growing of several highly susceptible varieties has caused the disease to become of increasing importance throughout the State. This smut destroys the entire head, replacing it with a mass of smut spores which are soon blown away by the wind, leaving only the central stem or rachis. The heads of normal wheat are shown in Figure 13 in contrast with heads destroyed by loose smut.

Loose smut is caused by a fungus that invades the young ovary at flowering time. Smut spores from diseased heads are blown to healthy heads, on which they germinate and penetrate the young seed. The fungus hyphae remain in the seed until it germinates. As the hyphae is within the seed and not on the surface, it cannot be killed

Figure 11. Wheat damaged by Septoria glume blotch near Childress, 1941.

with fungicides. When the seed is sown, the fungus resumes growth and advances systemically within the plant tissues, finally producing masses of smut instead of the normal grain and chaff.

Varieties differ in their reaction to this disease and to races of the fungus. Ponca, Pawnee, Triumph and Austin are resistant. Quanah, Concho, Kiowa and Bison are extremely susceptible and it is difficult to maintain disease-free seed. Other varieties, such as Comanche, Wichita and Westar, are susceptible when inoculated artificially, but seldom develop high infection under field conditions. The reactions of certain commercial varieties to artificial inoculation with loose smut are given in Table 5.

Damage from loose smut is inconspicuous because the spores are soon blown away, leaving only the bare rachis of the head, hence, the damage may be overlooked. Experimental tests have proved that, with moderate infections, the loss is roughly proportional to the percentage of spikes destroyed. Table 6 shows the results of a replicated test at Denton during 1949-52 where infected seed were introduced in given amounts into seed lots.

Figure 12. A normal wheat leaf (left) is shown in contrast with leaves infected in varying degrees with mildew.

Figure 13. Normal heads of wheat (left) contrasted with heads destroyed by loose smut.

Loose smut can be controlled by a rather complex soak and hot water treatment, but it is difficult to carry out on farms. A water-soak treatment was devised recently[1]. Briefly, this treatment is: partially fill burlap bags with wheat and soak in water at room temperatures for 6 hours, then place in a closed container (oil drum or barrel) with a tight lid for 72 hours and then spread out to dry. By this method, the organism is killed by excluding oxygen with little damage to the seed. Treated seed should be sown in a field isolated from fields sown with infected seed so the crop will not become reinfected.

Bunt or Stinking Smut

Stinking smut or bunt (*Tilletia foetida* (Wallr.) Liro) of wheat differs from loose smut in that the glumes and other parts of the head

[1] Weibel, D. E. and Atkins, I. M. The long water-soak method for controlling loose smut of wheat. Texas Station Progress Report 1986, 1947.

TABLE 5. REACTIONS OF COMMERCIAL VARIETIES TO ARTIFICIAL INOCULATION WITH LOOSE SMUT AT DENTON, 1956-57

Variety	1956	1957
Triumph	R	R
Wichita	S	VS
RedChief	S	S
Ponca	MS	S
Comanche	MS	S
Westar	MS	S
Pawnee	R	R
Concho	S	VS
Crockett	MR	MR
Quanah	S	VS
Frisco	S	VS
Knox	MS	MS

R = resistant, MR = moderately resistant, MS = moderately susceptible, S = susceptible, VS = very susceptible.

TABLE 6. YIELD REDUCTIONS IN RED MAY WHEAT CAUSED BY VARYING PERCENTAGES OF LOOSE SMUT AT DENTON, 1949-52

Percent smut	Average yield, bushels per acre	Percent reduction in yield
0	26.2	
5	24.5	—7.0
10	24.2	—9.0
25	21.4	—19.0
50	19.5	—26.0

remain intact and only the internal part of the kernel is replaced by smut. The smut balls resemble seed and often are overlooked until threshing time, when they are broken and the black spores scattered to healthy grain where they lodge in the brush at the end or in the crevice of the kernel. They remain there until seeding time when they germinate and the fungus germ tube enters the young seedling. The fungus hyphae then grow within the tissues of the host plant, finally replacing the kernels with a mass of spores. Normal and bunted heads with healthy kernels and smut balls are shown in Figure 14.

Bunt infection is influenced greatly by the temperature of the soil at seeding time. Soil temperatures below 68° F. are favorable for infection, higher temperatures are less favorable. This explains why the disease is more important on the High Plains of Texas than in Central Texas where soil temperatures are less favorable at seeding time.

Wheat grain from smutted plants will have a fishy odor, and if 14 or more smut balls are present in 250 grams of seed, the grain is graded "smutty" and sells at a lower price. The control of bunt is inexpensive and most commercial cleaning establishments have modern equipment for applying fungicides. These fungicides are

Figure 14. Normal head and grain of wheat (right) compared with a head in which the kernels were replaced with smut balls.

TABLE 7. REACTIONS OF SELECTED WHEAT VARIETIES ARTIFICIALLY INOCULATED WITH BUNT, DENTON, 1955-56

Variety	Percent infection	
	1955	1956
Triumph	50	50
Wichita	50	10
Early Blackhull	80	5
Apache	5	
Crockett	60	10
Quanah	0	5
RedChief	90	80
Kiowa	10	15
Bison		1
Ponca	60	15
Comanche	5	3
Westar	90	10
Concho	0	50
Frisco	50	10
Knox	5	80

effective in controlling bunt and they aid in controlling seedling diseases. Seed treatment is recommended even for resistant varieties since it may prevent an increase of rare races of bunt.

Varieties differ greatly in their reaction to this disease and to races of the organism. Quanah, Comanche, Concho, Bison, Kiowa and Apache are resistant to the more prevalent races in Texas. However, races that can attack these varieties are known to occur in small amounts and, therefore, seed treatment is advised. Table 7 gives the reactions of selected commercial varieties to artificial inoculation with bunt spores at Denton during 1955 and 1956.

Foot-rot or Root-rot

Recent research has indicated that *Helminthosporium sativum* (Pamm., King & Bakke) is probably the most important pathogen of this disease in wheat in Texas. In some other areas of the United States, *Fusarium* spp., *Rhizoctonia* spp., and some other species of fungi have been reported as pathogens causing foot-rots of wheat.

Early season symptoms of the foot-rot observed on the Rolling Plains include stunting, non-thrifty plants, reduced seedling growth and value for pasture, and extreme susceptibility to drouth. The disease is more severe when temperatures are slightly above optimum for the wheat plant. Near maturity, one or more tillers, or even entire plants, are killed, appearing as "white heads" throughout the field. Seed from these dead tillers and plants usually are shriveled, resulting in lowered yields and tests weights from the field. Although the disease often is not apparent until tillers and plants begin to die near maturity, the infection takes place at the time seedlings emerge. The organism invades the roots, crown and base of the culms of the plant. Roots are destroyed or reduced in extent and usefulness, as shown in Figure 15.

Foot-rot of wheat has been destructive in Foard, Baylor and Hardeman counties during the past 10 years and has been observed in several other counties. A field of wheat infected with foot-rot near Crowell in 1954 is shown in Figure 16.

Figure 15. Normal healthy roots of wheat plant are shown (left) in contrast with plants whose roots were damaged by foot-rot.

The control of foot-rot is difficult where continuous cropping of wheat is practiced. Continuous cropping provides a favorable situation for the pathogens that cause foot-rot to increase in the soil. Crop rotation with non-grass crops, such as legumes, is desirable, but difficult to carry out because few such crops are profitable in the major wheat-growing areas. Summer fallow will reduce the soil population of the causal pathogens, but usually is not economically feasible. Relatively little is known about varietal reaction, but no resistant, adapted variety is known. Seed treatment with organic mercury

Figure 16. Wheat field near Crowell in 1954 showing normal plants and other plants killed by foot-rot.

Figure 17. A normal head of wheat (right) contrasted with heads in which seed were set in only parts of the head because of the killing of the pollen by low temperatures.

fungicides will give some protection from seedling infection, but cannot control the disease because infection can occur at any time during the growing season.

Cold Injury

Injury from low temperatures at several stages of growth may be confused with disease or hail injury. Sometimes, these abnormalities are evident considerably later than the freeze and are not associated with the low temperature.

Wheat can be injured by low temperatures in such a manner that part of the tillers will break down, turn white and die several weeks later. Late-spring freezes may kill or damage the foliage and cause stunting until new tillers develop from the crown. Under some conditions, the leaves may produce new growth, then later the entire plant may die. Damaged or dead leaves and stems may be invaded by molds and other fungi so that the entire field may present a blackened, abnormal appearance.

Figure 18. Normal leaf of oats (left) contrasted with leaves infected with crown rust.

The most commonly observed abnormality is sterile or partly sterile heads as a result of the killing of the pollen or young ovary. This may happen with some varieties and under some conditions when the head is still in the boot. Temperatures below freezing as the crop is heading usually cause such abnormalities, but there is evidence that a temperature of 36° F. may kill the pollen. The stage of growth of each floret determines the degree of damage so that some heads may be sterile at the top while others are damaged at the base. Figure 17 shows examples of freeze damage.

DISEASES OF OATS

Oats were grown on an average of 1,130,900 acres during the 10-year period, 1947-56, but the use of oats has expanded in recent years. The official estimate of harvested area in 1958 was 1,361,000 acres, but the seeded area, which includes that sown exclusively for winter pasture, was 2,323,000 acres Most of the Texas acreage is fall sown, but when spring moisture conditions are favorable or the crop is winterkilled, large acreages may be spring sown.

Diseases are limiting factors in the growing of oats for grain and major factors in the use of the crop for forage in the humid sections of Texas. Many Texas growers seed oats as early in the fall as moisture conditions permit to get maximum use of the crop for livestock pasture. Rusts and other diseases may infect these fields in early fall in South Texas and, if conditions are favorable, may produce epidemics that reduce the value for pasture and may spread into the major grain-producing areas farther north. Crown (leaf) rust, stem rust, blights and smuts are major diseases of oats in Texas. Mildew, Septoria disease and virus diseases are relatively minor, but may be important locally.

Crown Rust

Crown or leaf rust (*Puccinia coronata* Cda., var. *avenae* Fraser & Led.) is probably the most destructive disease of oats in Texas. This disease is called crown rust because the teliospore, or overwintering spore, has a crown-like apex. Crown rust, like other rusts, is caused by a fungus that attacks the leaves and leaf sheath of oats and certain related grasses. The disease appears as tiny, round, yellowish-red pustules on either surface of the leaf blade. These pustules produce tiny yellowish-red spores that are spread to other plants by wind currents and germinate in free moisture from dews or rain Temperatures of 70 to 85° F. are most favorable for growth of the fungus and, under such conditions, a new pustule is formed in about 8 days. The pustules give rise to the teliospore or black overwintering spore as conditions become unfavorable or the crop matures.

Crown rust infection usually occurs in the fall in South Texas from spores blown south on

cold fronts or "northers," or they may be blown into South Texas from summer crops in Mexico. Because of these facts, the development of this disease during the winter in South Texas is of concern to growers throughout the Central States. Normal and crown-rust infected leaves are shown in Figure 18. Figure 19 shows a field of oats that was destroyed by crown rust at College Station in 1957.

The damage caused by crown rust may result in lowered yields of grain and, where the crop is used for winter pasture as in South Texas, the plants may be killed by the disease in the seedling stage. Thousands of acres were killed by crown rust in January 1951, resulting in the loss of several months of grazing. New races which can attack all present varieties grown in Texas, were prevalent in South Texas in 1958 and reduced the grazing period of oats in that area by about a month.

The organism causing crown rust of oats is made up of many races. These races differ in their ability to attack varieties and vary in prevalence from year to year, depending on the varieties grown and environmental conditions. New races of the crown rust fungus develop from time to time on the alternate host plants, the buckthorn, *Rhamnus* spp., and probably by hyphal fusion in the oat plant. The Victoria variety was used extensively in breeding oats in the South and the resistance to crown rust found in Alamo, Ranger, Victorgrain, Mustang and Bronco was derived from this source. While this resistance was very effective before 1957, new races, 213 and 216, which can attack these varieties, are now prevalent. Landhafer, Santa Fe and Trispernia are resistant to many races, including 213 and 216, but new races, 264 and 276, were found in Florida in 1955 that can attack these varieties. No presently adapted commercial variety is resistant to all races of crown rust. The responses of certain commercial varieties to some races are given in Table 8.

Stem Rust

Stem rust (*Puccinia graminis* Pers. f. sp. *avenae* Eriks. & E. Henn.) of oats is similar in appearance and behavior to that described for wheat. This subspecies, however, attacks oats and related grasses, but not wheat or barley. The red stage of the fungus attacks the leaves, stems and panicles of oats; the black spore stage (teliospore) is evident as the crop matures or the plants are killed. Rust-free and oat stems infected with stem rust are shown in Figure 20.

TABLE 8. REACTION OF SOME COMMERCIAL VARIETIES OF OATS TO CERTAIN RACES OF CROWN RUST

Variety	Older common races[1]	Race 202[1]	Races 213 and 216[1]	Races 264 and 276[1]
Camellia	R	MS	S	S
Ranger	R	R	S	S
New Nortex	MS	MS	MS	S
Alamo	R	R	S	S
Mustang	R	R	S	S
Victorgrain	R	R	S	S
Alber	MR	MR	MS	S
Arkwin	R	S	S	S
Suregrain	R	R	R	S

[1]R = resistant, MR = moderately resistant, MS = moderately susceptible, S = susceptible.

Figure 19. A field of oats destroyed by crown rust in 1957 at College Station.

The only practical method for controlling stem rust is growing resistant varieties. Alamo is the only variety adapted in Texas which is resistant to present prevalent races, but it is susceptible to race 7A. All other Texas varieties are susceptible to stem rust. Early varieties, such as Fulgrain, Frazier, Cimarron and Victorgrain, may escape damage because of early maturity.

Like those of the stem rust of wheat, the spores of stem rust of oats may be carried into Texas from Mexico, or from northern growing areas by cold fronts in the fall. Temperatures and moisture conditions often are favorable during the South Texas winters for establishing stem rust in the fall. The disease may reduce grain

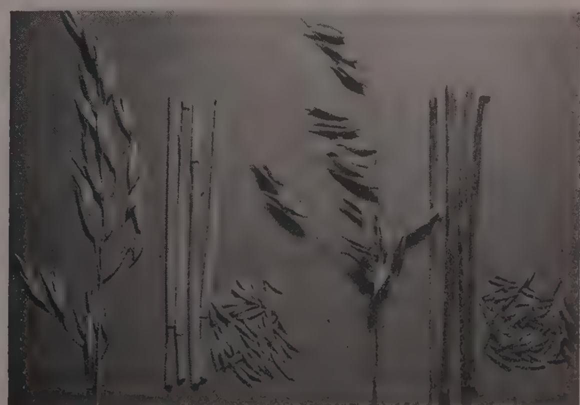

Figure 20. Normal panicle, stems and grain of oats (left) contrasted with panicle and stems infected with stem rust (right). Note shriveled seed from rust-infected plant.

Figure 21. A healthy panicle of oats (left) compared with one infected with covered smut and two infected with loose smut. The smut spores have been washed or blown off the panicle at the right.

yields and the forage value of oats sown for winter pasture. The disease spreads northward as the crop develops progressively from south to north.

Smuts

Two species of smuts (*Ustilago avenae* (Pers.) Rostr.) and (*Ustilago kolleri* Wille.) attack oats in Texas. Black loose smut destroys the entire panicle leaving only the central rachis; covered smut tends to be retained by the glumes and membranes. However, under field conditions, it sometimes is difficult to differentiate between them because rains or winds soon scatter the spores. The spores of the pathogens are spread by winds and by threshing of the grain. Spores lodge on healthy kernels and beneath the glumes where they remain as spores or as dormant mycelium until seeding time. The fungus penetrates the young seedling at germination time and grows systematically with the plant, finally replacing the panicle with a mass of smut spores. Figure 21 shows the two types of smut in contrast with a healthy panicle of oats.

TABLE 9. YIELDS OF SMUTTED AND SMUT-FREE FRAZIER, MUSTANG AND NEW NORTEX OATS AT COLLEGE STATION, 1958

Variety	Percent smutted panicles	Yield of grain, bushels per acre: Smutted seed	Yield of grain, bushels per acre: Smut-free seed
Frazier	2	23.4[1]	69.8
Mustang	54	15.5	66.4
New Nortex	38	57.1	76.6

[1]Yield reduction was due to poor germination of smutted seed.

Yields of oats are reduced and the quality of grain damaged by high infestations of smut. Some varieties may be damaged more than others. An experiment was conducted at College Station in 1958, where seed were inoculated with smut. Results obtained with three varieties are shown in Table 9.

Physiological races of both smuts are known and varieties differ in reaction to these races. Bronco and Alamo are resistant to many races, while Mustang and Fultex are very susceptible to Texas collections of smut. New Nortex is susceptible, but usually does not develop high percentages of smut under field conditions.

The smuts are easily controlled by seed treatment with the organic mercury compounds. Most commercial seed-cleaning establishments have equipment for applying fungicides. Seed treatment is recommended for all oat seed used for planting, regardless of whether smut was observed in the crop. Smut infection of seed may occur by windblown spores, through custom combines or by contamination from trucks, sacks or other means. Seed treatment usually improves germination by protecting the seedling from soil organisms that may attack it. Fungicides should be handled carefully and according to directions of the manufacturer. These products are poisonous to man and animals, and treated seed surplus to planting needs should not be fed to livestock.

Helminthosporium Blights

Three different blights (*Helminthosporium avenae* Eidam, *Helminthosporium sativum* Pam., King & Bakke, and *Helminthosporium victoriae* Meehan & Murphy) attack oats in Texas. The leaf blotch caused by *H. avenae* is characterized by oblong, linear, irregular blotches. The lesions are purplish-brown with sunken centers. When infection is high, the leaves turn brown and die. The causal fungus is carried from one season to the next on seed and crop residue. Crop rotation, sanitation and seed treatment with organic mercury fungicides reduce seedling infection.

The species *H. sativum* causes some seedling and leaf damage. It appears as severe blackening and rotting of the crown and lower part of the culm. Severe lodging, lowered yields and test weight result.

The blight caused by *H. victoriae* became widespread soon after varieties of Victoria parentage were distributed. The disease is often called Victoria blight. Characteristic symptoms are seedling blight, reduced stands, reddening of the leaves, decay of the roots and blackening of stems and nodes followed by lodging. Grain yields are reduced considerably, the grain may be of low test weight and discolored and it often heats in storage. The fungus produces a toxin

Figure 22. A normal plant of oats (left) contrasted with plants affected in varying degrees of severity by blight caused by Helminthosporium victoriae.

that moves systematically through the plant and causes many of the symptoms. As the plant matures or is killed, blackened fruiting bodies with olive-black spores are formed on plant surfaces, especially at the nodes. Normal plants and others damaged in varying degrees by Helminthosporium blight are shown in Figure 22.

The control of blight is difficult when susceptible varieties are grown because the disease is both seed and soilborne. Warm weather favors the disease; so, it is of greater importance in South Texas. Late-seeded spring oats are damaged more often than that seeded at normal dates. The disease usually is not destructive in the drier parts of the State and susceptible varieties may be grown on the Rolling and High Plains without appreciable damage. Crop rotation and the use of disease-free seed treated properly with fungi-

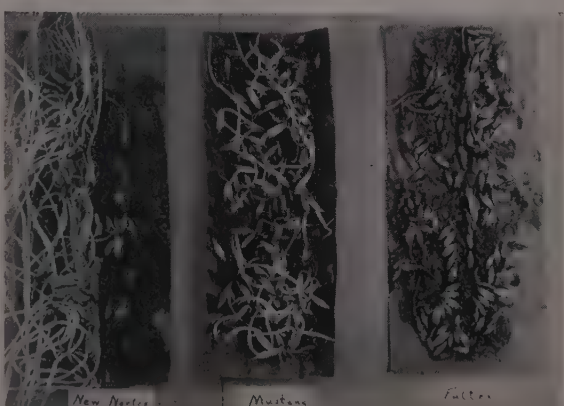

Figure 23. Germination of New Nortex (resistant), Mustang and Fultex (susceptible) oat seed in the presence of pure culture of the Helminthosporium blight organism.

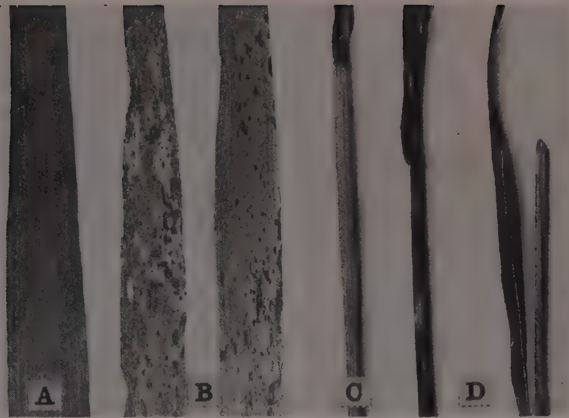

Figure 24. A—A normal leaf of oats compared with B—Septoria-infected leaf; C—Normal culm of oats compared with D—Septoria-infected culm.

cides will greatly reduce the chances of damage to the crop.

Varities resistant to Victoria blight should be grown when possible. Resistant varieties available include New Nortex (and other Red Rustproof strains), Camellia, Alber, Arkwin, Midsouth and Suregrain. Mustang and Bronco have shown some field tolerance in most years, but are susceptible in seasons favorable to the disease. Alamo, Fultex, Victorgrain, Ranger and Rustler are susceptible. A method of evaluating varieties for reaction to the disease has been developed. It consists of germinating seed in the presence of large amounts of inoculum. The results of such a test and its effect on Fultex, Mustang and New Nortex are shown in Figure 23.

Septoria Disease

The Septoria disease (*Septoria avenae* Frank (*Leptosphaeria avenaria* Weber the perfect stage) or *Septoria tritici* Rob. ex Desm. *avenae* (Desm.) Sprague) had not been observed in Texas until the very wet, cool seasons of 1957 and

Figure 25. Normal panicle of oats (left) contrasted with panicles damaged by blast.

Figure 26. Normal leaf of barley (right) contrasted with leaves infected with net blotch.

1958. The behavior of the disease was different in the two seasons. On the basis of field reaction and laboratory tests, it is believed that both the species listed above were involved.

The leaf blotch was observed even before the heading stage as dark-purple to brown spots of varying size. Some leaves were nearly destroyed by the infection. Later infection was observed on the stems as blackened spots spreading and coalescing until much of the stem was discolored. There was considerable lodging before the crop matured. The Red Rustproof strains were moderately resistant in 1957, but no variety was observed to be resistant in 1958. Whether the disease will continue to be of importance cannot be determined at this time. Diseased and healthy culms and leaves are shown in Figure 24.

Figure 27. Symptoms of spot blotch of barley.

Yellow Dwarf

Yellow dwarf is a virus disease of oats and barley. Under some conditions it has been called red leaf. Infected oat plants have a characteristic salmon-pink to red color and the plants are dwarfed. The degree of dwarfing that occurs depends on the stage of growth reached by the plant at the time of infection. When a plant is infected immediately after emergence it may be dwarfed so severely that it will fail to head. Reduced spike formation and filling of kernels may result from midseason infection. Infection that takes place at later stages may not damage the plant seriously. A barley plant infected by yellow dwarf is shown in Figure 35.

Blast

Blast is a nonparasitic abnormality which may be found in varying degrees depending on environmental conditions and the variety. Some varieties are much more subject to this injury than others. The lower part of the panicle, or most of it, may produce white, sterile florets. The condition is most prevalent under adverse conditions such as high temperature, deficient moisture and probably other factors. Figure 25 shows normal and blasted panicles of oats.

DISEASES OF BARLEY

The average harvested area of barley in Texas during the 10-year period, 1947-56, was 120,200 acres and was distributed over a large portion of the State. A 1957 survey showed that barley was grown in 182 of the 254 counties. Diseases cause less damage to barley than to other small grains because the crop matures early when conditions are somewhat unfavorable for many diseases. Net blotch, powdery mildew and leaf rust are the most important diseases, although stem rust and the smuts cause some damage. Spot blotch, barley scald, false stripe, bacterial blight and yellow dwarf have been observed in some seasons, but have caused only minor losses.

Net Blotch

Net blotch (*Pyrenophora teres* (Died.) Drechs.) has increased in importance in recent years because of the expanded acreages of the Goliad variety which is highly susceptible. Barley may be attacked in the seedling or later stages. Characteristic symptoms are brown spots on the leaves that expand and coalesce with other spots to form elongated, brown-netted areas which finally may cover most of the leaf and destroy its usefulness. The glumes of the head or spike also may be attacked, resulting in re-

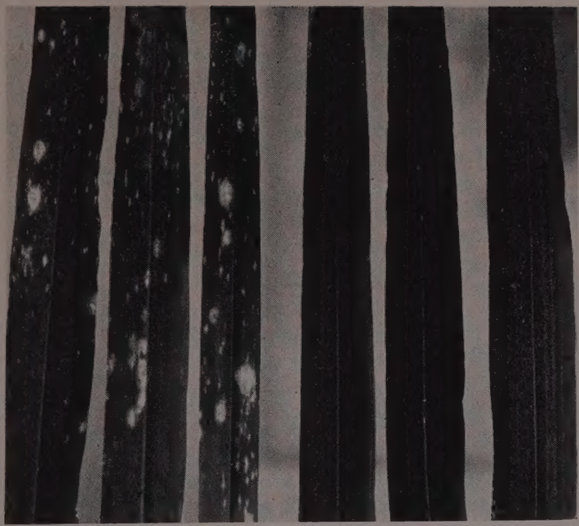

Figure 28. Normal barley leaves at right in contrast with leaves infected with barley mildew.

duced yields and shriveled seed. The fungus causing net blotch may be carried on the seed or infection may come from old straw. Sanitation, crop rotation and seed treatment with organic mercury fungicides aid in controlling the disease, but the most effective control is growing resistant varieties. Unfortunately, none of the Texas adapted varieties is highly resistant although some appear to be more tolerant than others to net blotch. A normal leaf and leaves infected with net blotch are shown in Figure 26.

Spot Blotch

The organism causing spot blotch (*Helminthosporium sativum* Pam., King & Bakke) of barley also attacks wheat and several grasses.

Figure 29. Normal leaves of barley (left) contrasted with leaves infected with leaf rust.

Figure 30. Healthy leaves of barley (left) contrasted with leaves infected with bacterial blight.

The young seedling, crown and roots are attacked soon after emergence, often resulting in reduced stands and a weak root system. The leaf spot occurs on the leaves, leaf sheath and floral parts, forming a characteristic "black point" kernel. Plants are weakened by the disease, resulting in lower yields and reduced bushel weight.

The pathogen causing spot blotch can be soil or seedborne, or it may be on crop residues. Seed treatment with organic mercury fungicides reduces losses from seedling infection. Destruction of crop residues and crop rotation aid in control. The use of resistant varieties offers the most practical means of control, but, of adapted varieties grown in Texas, only Goliad is resistant. Symptoms of spot blotch are shown in Figure 27.

Powdery Mildew

Mildew (*Erysiphe graminis* DC. f. sp. *hordei* Em. Marchal) occurs on barley in Texas during cool, humid weather, usually during the winter or early spring. The gray, fluffy mycelium of the fungus observed on the leaves and leaf sheaths also penetrates and invades the leaf tissue. As the disease progresses, the leaf turns

Figure 31. Normal leaves of barley (left) contrasted with leaves infected with barley false stripe.

Figure 32. Normal leaf of barley (right) contrasted with leaves infected with barley scald.

yellow and is gradually killed. Later, dark fruiting bodies containing the overwintering spores occur throughout the mass of fungus mycelium on the leaf.

The spores are carried from plant to plant by wind currents. While the disease can be controlled by fungicides, such control is not practical. Fortunately, most of the recommended va-

Figure 33. Normal head of barley (right) contrasted with heads destroyed by covered smut.

rieties have considerable resistance to races prevalent in Texas. Goliad, Cordova, Texan and Harbine have been resistant for a number of years, but Wintex, Tenkow and the Tennessee Winter strains are highly susceptible. Normal leaves of barley and others infected with powdery mildew are shown in Figure 28.

Leaf Rust

Leaf rust (*Puccinia hordei* Otth.) of barley is similar to the related species that attack wheat and oats, previously described. Barley leaf rust attacks barley and a few related grasses, but usually not wheat or oats. The tiny, round pustules of rust are light red and relatively inconspicuous. Like spores of other rusts, they may be carried into South Texas in the fall by cold fronts or may be blown in from Mexico. The disease may develop slowly in South Texas during the winter and then move northward as the season progesses. The only practical control is growing resistant varieties. None of the adapted commercial varieties grown in Texas is highly resistant to present prevalent races, although Goliad, Harbine and Rogers are moderately resistant. A normal leaf of barley is shown in contrast with leaves infected with leaf rust in Figure 29.

Stem Rust

Barley is attacked by the same organism (*Puccinia graminis tritici* Pers. var. Eriks.) that causes stem rust of wheat and rye. Stem rust of wheat was described previously. Losses in barley from this disease usually are small, but barley may serve as a host for overwintering of the pathogen in South Texas. Goliad is resistant to many races of stem rust and was developed to reduce the opportunity for overwintering of rust in South Texas. All other commercial varieties grown in the State are susceptible.

Bacterial Blight

Bacterial blight (*Xanthomonas translucens* (L. R. Jones, A. G. Johnson, and Reddy) Dowson) usually is a minor disease in Texas, but may cause damage in some fields. The symptoms are linear, water-soaked areas on the leaves which develop usually during damp, rainy weather. Small droplets of white exudate form on the light yellow to brown colored diseased areas. Insects are attracted by this gummy material and carry it along with bacteria to other plants. So far as is known, all commercial varieties adapted in Texas are susceptible. Bacterial blight-infected leaves are shown in contrast with healthy leaves in Figure 30.

False Stripe

False stripe is caused by a seedborne virus. The most evident symptoms are on the leaves, although, in severe attacks, some sterility of the head may result. Long, light-brown, mottled streaks appear on the leaves and these enlarge

into long stripes with irregular margins. The disease is spread by contact of leaf to leaf. As more plants become infected, there is a gradual decline in grain yields and quality. Seed from diseased fields should be discarded and a new supply of disease-free seed obtained. No other means of control is known. The relative resistance or susceptibility of Texas varieties is not known. Normal barley leaves are contrasted with leaves infected with false stripe in Figure 31.

Scald

Barley scald (*Rhynchosporium secalis* (Oud.) J. J. Davis) attacks barley, rye and some grasses. The disease was observed in Texas during 1957 and 1958. Typical symptoms are inconspicuous blotches, varying from a fraction of an inch in diameter to lesions that cover most of a leaf. The lesions are at first water-soaked in appearance, but, as the name implies, the leaf later looks as if it had been scalded. When large areas of tissue are involved, the yield of grain may be reduced greatly.

The pathogen causing scald is carried to the next season on seed and crop residues. Seed treatment with organic mercury fungicides will reduce seedling infection. Crop rotation and plowing the residues under will aid in controlling the disease. Varieties differ in their reaction to the disease. A normal barley leaf and others infected with scald are shown in Figure 32.

Covered Smut

Covered smut (*Ustilago hordei* (Pers.) Lagerh.) is so-called because the fungus destroys the barley kernels, but usually the floral bracts remain intact and hold the balls of smut until the grain is threshed. The threshing operation scatters the smut spores to healthy seed, where they lodge in or under the glumes and remain there until the seed are planted.

The infection occurs as the seed germinate. At this time, the spore also germinates and the fungus enters the young seedling. Infection is influenced by temperature and moisture; therefore, the amount of smut varies greatly from season to season, depending on weather conditions at seeding time. The fungus grows within the plant tissues and, at maturity, replaces the kernel with a mass of smut spores. Since the spores are carried on the seed, they may be killed by fungicides. Seed treatment is inexpensive and is recommended to control smuts and other seed-borne diseases. Although some varieties are known to be resistant, the adapted Texas varieties are susceptible. A healthy barley head and two that have been destroyed by covered smut are shown in Figure 33.

Loose Smut

Two types of loose smut (*Ustilago nuda* (Jens.) Rostr.) and (*Ustilago nigra* Tapke) attack barley and they cannot be distinguished in the field. The true loose or brown smut, *U. nuda*, is similar to wheat loose smut in that it infects the ovary at blooming time and remains as dormant mycelium within the seed. When the seed are sown, the fungus resumes growth and

Figure 34. Normal head of barley (right) contrasted with heads destroyed by loose smut.

Figure 35. A barley plant stunted by yellow dwarf is shown in the foreground and contrasted with normal plants in the background.

systemically invades the tissues, finally replacing the floral parts with a mass of spores. The amount of infection which takes place is influenced greatly by humidity and temperature at flowering time.

Because the fungus causing loose smut is within the mature seed as dormant mycelium, it is difficult to control and cannot be killed by surface fungicides. Until recently a complex hot-water treatment was used to kill the fungus in seed. A new method has now been devised. This method[3] is: soak the seed in water at room temperature for 2 to 6 hours. Place them in a barrel or other container with a tight lid and hold them under these conditions for 34 to 38 hours. Dry the grain immediately to prevent sprouting and to permit normal seeding.

Varieties differ in their reaction to loose smut. Some are highly resistant. Fortunately, several adapted varieties have resistance to some races and have remained free of the disease under commercial conditions in Texas. These include Goliad, Wintex, Texan, Cordova and Harbine. Reno and Ward are susceptible.

The black or semiloose smut, *U. nigra*, differs from brown loose smut in that the spores lodge on or within the glumes so that they can be reached by surface disinfectants. The smutted heads are similar to those of the true loose smut, but the smut usually appears later and the spores are shed over a longer time because the membranes are less damaged. Wintex, Texan and Cordova are susceptible to the black loose smut, as are most other adapted varieties. Seed treatment with mercury fungicides is recommended for the control of this smut. A normal head of barley and heads destroyed by loose smut are shown in Figure 34.

[3] Brown loose smut of barley. North Carolina Extension Folder 132 by J. C. Wells and T. T. Herbert.

Yellow Dwarf

Yellow dwarf is a virus disease of oats and barley. It has been present for some time in California, causing serious losses in 1953, and was observed in Texas in 1956. The disease may have been present for some time, but previously was assumed to be non-parasitic in nature or due to nutritional disturbances. On barley, the symptoms include bright-yellow coloration of leaf blades and severe dwarfing of plants, as shown in Figure 35.

The disease is transmitted by insects. Several species of aphids are known to be vectors and perhaps other insects may transmit the disease. The control of these insects with insecticides may aid in controlling the spread of the virus, but this usually is not practical with small-grain crops. No other control method is known.

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